

Description

5 The invention relates to a servo valve for an injection valve of the type mentioned in the precharacterizing clause of Patent Claim 1 for fuel injection in internal combustion engines. Such a servo valve is disclosed by DE-A-196 18 468.

10 For the fuel supply of internal combustion engines, use is increasingly being made of reservoir injection systems, in which operations are carried out with very high injection pressures. Such injection systems are
15 known as common rail systems (for diesel engines) and HPDI injection systems (for spark ignition engines). These injection systems are distinguished by the fact that the fuel is delivered by a high-pressure pump into a pressure reservoir which is common to all cylinders
20 of the engine, from which the injection valves on the individual cylinders are supplied. The opening and closing of the injection valves is as a rule controlled electromagnetically, possibly also with the aid of piezoelectric elements.

25 The servo valve is used to effect the opening and closing of the actual fuel injection valve hydraulically, that is to say in particular to define the start and the end of the injection operation
30 ~~exactly in time.~~ The servo valve, in conjunction with control restrictors, primarily influences the speed at which the injection valve opens and closes. For combustion reasons, the speed at which the injection valve opens should be different from the speed at which
35 the injection valve closes.

The injection valve should, for example, open slowly in a controlled manner and close quickly at the end of the injection operation. In addition, the injection of

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extremely small quantities of fuel for pre-injection (pilot injection) before the actual injection should be possible, with which the combustion process may be optimized. The quality of the combustion is, however,
5 also dependent on the closing speed (soot formation as a result of excessively slow closing).

The servo valve of a common rail system has previously existed substantially in two designs, which may in
10 principle be classified into one of the two types 2/2-way valve and 3/2-way valve.

These two types will be explained in more detail by using Figures 1 and 2 of the drawing. Figure 1 shows a
15 known injection valve with a 2/2-way valve as servo valve, and Figure 2 shows a known injection valve with a 3/2-way valve as servo valve.

As shown in Figures 1 and 2, in the case of both
20 embodiments, the fuel and system pressure is led from a high-pressure reservoir to a control chamber 1 in the injection valve. Arranged between the high-pressure reservoir and the control chamber 1 is a feed restrictor 2. In the control chamber 1, the pressure
25 prevailing there acts on the rear end of a movable nozzle body 6 which, during its movement, opens and closes injection holes 7 which lead to the combustion chamber of the internal combustion engine. Also connected to the high-pressure reservoir is a nozzle
30 chamber 8 at the front end of the nozzle body 6. When the full system pressure is present both in the control chamber 1 and in the nozzle chamber 8, the nozzle body 6 is forced downwards on account of the larger effective area in the control chamber 1, and closes the
35 injection holes 7.

Furthermore, it is common to both embodiments that the servo valve 4 is connected hydraulically to the same high-pressure reservoir (also called a common rail),

from which the fuel for the injection is also taken. The servo valve 4 has the task of controlling the pressure which is exerted on the movable nozzle body 6 in the control chamber 1 in order to close and open the injection valve. The servo valve 4 is in turn controlled electronically by an actuator 5 (for example by means of an electromagnet or a piezoelectric element).

As Figure 1 reveals, in the case of a servo valve 4 in the form of a 2/2-way valve, the control chamber 1 is connected to the high-pressure reservoir via a feed restrictor 2. From the control chamber 1, a connection with a discharge restrictor 3 leads to the servo valve 4. The servo valve 4 is in turn connected to a fuel pressure line, which leads to the fuel tank.

If the servo valve 4 is closed, the full system pressure is present in the control chamber 1, so that the nozzle needle at the front end of the nozzle body 6 closes the injection holes 7 which lead into the combustion chamber. Suitable activation of the electromagnetic or piezoelectric actuator 5 effects opening of the servo valve 4. When the servo valve 4 is open, a steady-state flow is established between the high-pressure reservoir, control chamber 1 and servo valve 4. This flow leads to a defined pressure drop at the individual restrictors, the feed restrictor 2 and the discharge restrictor 3, as a result of which, in particular, the pressure in the control chamber 1 is dissipated. As a result, the force acting on the nozzle body 6 is reduced, so that the injection valve is opened hydraulically by the system pressure present in the nozzle chamber 8.

This embodiment with a 2/2-way valve has the critical disadvantage that the opening and closing operations of the injection valve can be influenced independently

only within very close limits by the configuration of the feed and discharge restrictors.

As Figure 2 reveals, in the embodiment with a 3/2-way valve, the feed leads to the control chamber 1 via the feed restrictor 2, the servo valve 4 and the discharge restrictor 3. The discharge leads to the return line via the discharge restrictor 3 and the servo valve 4.

With this arrangement, the control chamber 1 can be decoupled completely from the system pressure when the servo valve 4 is opened. The pressure in the control chamber 1 can be dissipated via the discharge restrictor 3 without any influence of the feed restrictor 2. Therefore, in principle, quicker opening of the injection valve than in the case of the 2/2-way valve is possible. After the discharge on the 3/2-way valve has been closed, the system pressure in the control chamber 1 is built up again via the feed restrictor 2 and the discharge restrictor 3.

There is therefore the possibility of slowing the closing operation of the injection valve with the feed restrictor 3.

As opposed to this, however, in the case of injection valves for internal combustion engines, the desire is generally to slow the opening of the injection valve, while the closing is to proceed quickly.

DE-A-196 18 468, mentioned at the beginning, discloses an injection valve with a hydraulically actuated control piston, which seals off the control chamber at the top and is provided with a discharge restrictor in the form of a bore. Arranged between the control piston and the nozzle body of the injection pump is a spring. A control valve, in interaction with a number of further restrictors, controls the pressure acting on the control piston. If the control valve is closed

when the injection valve is open, the control piston opens a connection between a fuel feed duct and the control chamber, so that the fuel flows directly into the control chamber and the injection stops abruptly.

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In this arrangement, the servo valve comprises the two components control piston and control valve, whose interaction is controlled hydraulically via pressure chambers and restrictors. In this arrangement, however, 10 the mass of the control piston, not directly connected to the nozzle needle, causes additional system inertia.

The invention is based on the object of configuring the servo valve in such a way that the opening and closing 15 operations of the injection valve can be influenced in a relatively simple manner independently of one another. It is also intended to be possible to inject extremely small quantities of fuel in a controlled manner.

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According to the invention, this object is achieved by the alternative servo valve arrangements specified in the collateral Patent Claims 1, 4 and 6.

25 Advantageous refinements of the servo valve arrangements according to the invention are described in the subclaims.

The invention constitutes a variant of the 3/2-way 30 valve, independent influencing of the opening and closing operations of the injection valve being achieved in the following, alternative ways:

35 (1) According to the invention, use is made of the fact that, when opening and closing the injection valve, the flow path (the connecting bore) between the control chamber and the servo valve has flow through it in opposite directions. The opposed flows may be influenced differently. One possible

type of influence, which is specified in Patent Claim 1, resides in a functional design of the discharge restrictor as a self-regulating valve in the form of a movable piston which, for each flow direction, opens and closes a different flow cross section. The piston is preferably actuated hydraulically only by the flow. An alternative type of influence, which is cited in Patent Claim 4, is carried out by means of shaping the restrictor which, with respect to one flow direction, is asymmetrical in the flow direction with a cross section which tapers gradually and then widens abruptly and, with respect to the other flow direction, a cross section which decreases abruptly and then widens gradually, the restrictor acting as a continuously narrowing nozzle or as a continuously widening diffuser, depending on the flow direction. Since the flow resistance of a nozzle differs from that of a diffuser, by means of this type of cross section narrowing, the flow resistance in the two directions can be varied over a wide range. The flow behaviour is also influenced by the step or discontinuous widening/narrowing at the outlet/inlet of the nozzle/diffuser. Overall, a high flow velocity in the direction of the control chamber permits rapid closing of the injection valve.

(2) According to the invention, the discharge restrictor is only arranged after the servo valve, that is to say between servo valve and return to the fuel tank... The discharge restrictor therefore influences only the emptying of the control chamber, that is to say the opening of the injection valve. This is possible because the 3/2-way valve, when opened, interrupts the connection between the control chamber and the high-pressure reservoir, which is at the system pressure. Therefore, the discharge restrictor is active only when the servo valve is open. When the servo valve

is closed, the connection to the fuel tank is interrupted and the connection between control chamber and high-pressure chamber reservoir is produced again. The pressure in the control chamber can therefore be produced again quickly without restriction, and therefore the injection valve can be closed quickly, which meets the general requirements on a common rail injection system.

If appropriate, by installing a feed restrictor, fine tuning may be carried out on the filling of the control chamber and therefore the closing of the injection valve. The opening of the injection valve is not affected as a result.

The present invention has the advantage that, by means of variants of the concept with a 3/2-way valve, which can be implemented relatively simply, largely independent setting of the opening and closing operations of the injection valve can be achieved.

In the following text, the invention will be explained in more detail by way of example using the drawing, in which:

Figure 1 shows a known injection valve with a 2/2-way valve as servo valve in schematic form;

Figure 2 shows a known injection valve with a 3/2-way valve as servo valve in schematic form;

Figure 3A shows an injection valve according to the invention with a first embodiment of the servo valve;

Figure 3B shows an injection valve according to the invention with a second embodiment of the servo valve;

Figure 3C shows an injection valve according to the invention with a third embodiment of the servo valve;

Figure 3D shows an injection valve according to the invention with a fourth embodiment of the servo valve;

Figure 4 shows a detail view of the piston used in the first embodiment of the servo valve of Figure 3A;

Figure 5 shows a detail view of the restrictor used in the second embodiment of the servo valve of Figure 3B.

Figures 3A to 3D show various alternative embodiments of an injection valve with a 3/2-way valve modified in accordance with the invention as a servo valve 4. The common factor in all the embodiments is that the system pressure present in the high-pressure reservoir is supplied via a high-pressure bore 17 both to the valve chamber 11 of the servo valve 4 and to the nozzle chamber 8 at the front end of the nozzle body 6 of the injection valve. For this purpose, a feed bore 18 leads from the high-pressure bore 17 to the valve chamber 11, and a connecting bore 19 leads from the valve chamber 11 to the control chamber 1 at the rear end of the nozzle body 6. The valve body 10 of the servo valve 4 is pressed against a valve seat 15 by the system pressure in the initial state, so that there is no connection between the valve chamber 11 and the return 21 to the fuel tank. The system pressure is present on the nozzle body 6 via the feed bore 18 and the connecting bore 19, so that the nozzle needle 6a at the front end of the nozzle body 6 is pressed into its seat. The connection between the injection holes 7 and the nozzle chamber 8 is therefore interrupted, and no fuel from the nozzle chamber 8 can be injected into the combustion chamber.

When the actuator 5 is actuated, a force is exerted on the servo valve 4 via the plunger 9, lifts the valve body 10 off the valve seat 15 and presses it against a sealing face 16 at the inlet of the feed bore 18 into the valve chamber 11, such that the connection between the feed bore 18 and the valve chamber 11 is interrupted. On the other hand, as a result of the valve body 10 lifting off the valve seat 15, the connection between the valve chamber 11 and the return 21 is opened. The return 21 connected to the fuel tank is unpressurized. The pressure in the control chamber

1 can therefore be dissipated completely via the
connecting bore 19 and the valve chamber 11. The
nozzle body 6 is thus relieved of load, so that the
pressure present in the nozzle chamber 8 lifts the
5 nozzle needle 6a off its seat and opens the connection
to the injection holes 7. The injection operation
therefore begins.

After the conclusion of the driving of the actuator 5,
10 the system pressure present in the feed bore 18 presses
the valve body 10 into the valve seat 15 again, so that
the valve body 10 lifts off the sealing face 16, and
the valve chamber 11 and, via the latter and the
15 connecting bore 19, the control chamber 1 are again
subjected to the system pressure. In order to assist
the valve closing operation at the servo valve 4, a
valve spring 12 is provided on the valve body 10 and
exerts a force on the valve body 10 in the direction of
the valve seat 15.

20 The pressure in the control chamber 1 leads to a force
on the nozzle body 6 in the direction of the seat of
the nozzle needle 6a, which presses the nozzle needle
6a into its seat again and ends the injection
25 operation. In order to assist the injection valve
closing operation at low system pressures, a nozzle
spring 6b is provided, which presses the nozzle needle
6a against its seat.

30 The speed at which the injection valve opens and closes
is influenced directly by the speed at which the
pressure in the control chamber 1 is dissipated and
built up again. The closing operation should as a rule
proceed as quickly as possible, for which reason the
35 fuel supply and therefore the pressure build-up is
generally carried out in an unrestricted manner. On
the other hand, the opening of the injection valve
should proceed in a controlled manner. To build up the
pressure in the control chamber 1 in a specific way,

use is made of a discharge restrictor 3 in the various design variants of Figures 3A to 3D.

5 Figure 3A shows a first design variant of the discharge restrictor 3. The restrictor 3 is designed as a piston 3A, which is arranged in a chamber between the control chamber 1 and the connecting bore 19. The piston 3A can move freely between a sealing face 305 on the side of the connecting bore 19 and a shoulder 303 on the side of the control chamber 1. The shoulder 303 can be formed by a ring inserted into the chamber for the piston 3A from the side of the control chamber 1.

15 As Figure 4 shows, in the region of the opening of the connecting bore 19, the piston 3A has a discharge opening 301 and, in the region of the sealing face 305, one or more feed openings 302.

20 When the actuator 5 is actuated and the servo valve 4 opens the connection to the return 21, fuel flows out of the control chamber 1 through the openings in the piston 3A into the connecting bore 19. Across the piston 3A there is produced a pressure gradient, which forces the piston 3A against the sealing face 305 and closes the feed openings 302. Only the discharge opening 301 forming a discharge restrictor is available for the fuel flowing away.

30 In the opposite case, when, with the valve closed, fuel flows out of the connecting line 19 into the control chamber 1, the piston 3A is released from the sealing face 305 and comes to rest on the shoulder 303. As a result, the feed openings 302 are opened.

35 By means of different dimensioning of the openings 301 and 302, the flow velocity during emptying and filling the control chamber 1 can be set independently. For example, the discharge opening 301 will as a rule have

a relatively small diameter, and the cross section of the feed opening(s) 302 will be relatively large.

5 Instead of through-holes, as shown, the feed and/or discharge openings 301, 302 can also be formed as grooves in that side of the piston 3A which rests on the sealing face 305.

10 Figure 3B shows a second design variant of the restrictor 3. The restrictor 3 is designed as a cross section narrowing 3B in the connecting bore 19, the cross section of the narrowing 3B decreasing gradually down to a minimum in the direction of the longitudinal axis of the connecting bore 19 and then, abruptly, as a
15 step or discontinuously, widening again to the diameter of the connecting bore 19. Figure 5 shows an enlarged detail view of the narrowing 3B in the connecting bore 19. On account of its shape, the cross section narrowing 3B acts on the flow in one direction as a
20 continuous narrowing or nozzle (with a following discontinuous widening) and on the flow in the opposite direction as a discontinuous narrowing with a following continuous widening or a diffuser. Since a nozzle has a different flow resistance from that of a diffuser, the
25 flow resistance at the narrowing 3B is greater for a flow in one direction than in the opposite direction.

By means of appropriate configuration of the narrowing 3B, therefore, with this design variant, too, the speed
30 at which the control chamber 1 empties and fills again can be set over a wide range. The flow resistance of a nozzle depends substantially only on the ratio of the narrowest cross section to the tube cross section of the connecting bore 19. Furthermore, the taper of the
35 continuous cross section widening plays a role for the flow resistance. Therefore, the flow resistance in the two flow directions may be influenced differently by two mutually independent parameters.

Figures 3C and 3D show two further design variants of the restrictor 3. In these variants, the restrictor 3 is integrated into the return 21 which leads from the servo valve 4 to the fuel tank. In general, in injection valves, the plunger 9 which is arranged such that it can move between the actuator 5 and the valve body 10 of the servo valve 4, or the guide bore in which the plunger 9 moves, is designed in such a way that fuel conveyed back to the fuel tank in the return 21 can flow past the plunger 9 without great flow losses. This can be carried out, for example, by means of flats machined laterally into the plunger or a groove machined into the bore, which leave an adequately large flow cross section free for the return flow. As opposed to this, in the case of the two design variants of Figures 3C and 3D, the plunger 9 is provided with a guide 901 which is fitted so accurately into the bore in the valve housing that this guide 901 closes the plunger bore in a substantially fuel-tight manner.

As Figure 3C shows, one design variant of the restrictor 3 consists in a restrictor groove 3C which forms the discharge restrictor, is formed laterally in the guide 901 and through which the fuel flows along the plunger 9 in a restricted manner when the valve body 10 of the servo valve 4 has lifted off the valve seat 15.

As Figure 3D shows, in the other design variant of the restrictor 3, underneath a more or less completely sealed guide 902 for the plunger 9, a branch 22 is provided in the return 21, through which branch the fuel flows on its path from the servo valve 4 to the fuel tank. The branch 22 has a reduced cross section at at least one point, which represents a restrictor bore 3D.

In the two design variants of Figures 3C and 3D, too, the cross section of the restrictor groove 3C or the cross section of the restrictor bore 3D in the return 21 or the branch 22 can be defined independently such that the desired opening and closing behaviour of the injection valve is obtained. The special configuration of the discharge restrictor in the design variants of Figures 3A and 3B and, respectively, the arrangement of the discharge restrictor 3 in the return 21 after the servo valve 4 in the design variants of Figures 3C and 3D ensure that the feed of the fuel from the high-pressure bore 17 to the control chamber 1 is not hindered and, on the other hand, any possible feed restrictor in the feed bore 18 or any restriction of the fuel flowing in at the opening of the feed bore 18 into the valve chamber 11 does not affect the discharge of the fuel from the control chamber 1 through the return 21.

Patent claims

- 5 1. Servo valve for an injection valve for the
injection of fuel into an internal combustion
engine, comprising a control chamber (1) which is
acted on with fuel under system pressure from a
high-pressure reservoir and which can be connected
10 to a fuel tank via a discharge restrictor (3)
having an unpressurized return (21), the pressure
prevailing in the control chamber (1) acting on a
movable nozzle body (6) which is provided with a
nozzle needle (6a) which opens and closes
15 injection holes (7) during the movement of the
nozzle body (6), and the fuel flow to and from the
control chamber (1) being controlled by the servo
valve (4), which has a movable valve body (10) and
which, selectively, produces a connection between
20 the control chamber (1) and the high-pressure
reservoir or a connection between the control
chamber (1) and the unpressurized return (21),
characterized in that the discharge restrictor (3)
is designed as a movable piston (3A) with an
25 output opening (301), which is arranged in a
chamber between the control chamber (1) and the
servo valve (4), the piston (3A), when there is a
flow of fuel into the control chamber (1), opening
at least one feed opening (302) which is closed
30 when there is a flow of fuel out of the control
chamber (1).
2. Servo valve according to Claim 1, characterized in
that the piston (3A) is arranged in a chamber
35 adjoining the control chamber (1).
3. Servo valve according to Claim 1, characterized in
that a sealing face (305) lies opposite the piston

(3A) on the servo valve side in the region of the feed openings (302).

4. Servo valve for an injection valve for the injection of fuel into an internal combustion engine, comprising a control chamber (1) which is acted on with fuel under system pressure from a high-pressure reservoir and which can be connected to a fuel tank via a discharge restrictor (3) having an unpressurized return (21), the pressure prevailing in the control chamber (1) acting on a movable nozzle body (6) which is provided with a nozzle needle (6a) which opens and closes injection holes (7) during the movement of the nozzle body (6), and the fuel flow to and from the control chamber (1) being controlled by the servo valve (4), which has a movable valve body (10) and which, selectively, produces a connection between the control chamber (1) and the high-pressure reservoir or a connection between the control chamber (1) and the unpressurized return (21), characterized in that the discharge restrictor (3) is designed as a cross section narrowing (3B) in a connecting bore (19) between the valve chamber (11) of the servo valve (4) and the control chamber (1), and in that the flow resistance at the cross section narrowing (3B) for a flow in the direction from the valve chamber (11) to the control chamber (1) is lower than for a flow in the opposite direction.

5. Servo valve according to Claim 4, characterized in that the cross section of the narrowing (3B) decreases gradually down to a minimum in the direction of the longitudinal axis of the connecting bore (19) and then widens discontinuously again as a step to the diameter of the connecting bore (19).

6. Servo valve for an injection valve for the injection of fuel into an internal combustion engine, comprising a control chamber (1) which is acted on with fuel under system pressure from a high-pressure reservoir and which can be connected to a fuel tank via a discharge restrictor (3) having an unpressurized return (21), the pressure prevailing in the control chamber (1) acting on a movable nozzle body (6) which is provided with a nozzle needle (6a) which opens and closes injection holes (7) during the movement of the nozzle body (6), and the fuel flow to and from the control chamber (1) being controlled by the servo valve (4), which has a movable valve body (10) and which, selectively, produces a connection between the control chamber (1) and the high-pressure reservoir or a connection between the control chamber (1) and the unpressurized return (21), characterized in that the discharge restrictor (3) is arranged in the return (21) after the servo valve (4).

7. Servo valve according to Claim 6, characterized in that the discharge restrictor is formed as a restrictor groove (3C) in a guide (901) of a plunger (9) for actuating the servo valve (4).

8. Servo valve according to Claim 6, characterized in that the discharge restrictor is formed as a restrictor bore (3D) in a branch (22) of the return (21) between the valve chamber (11) of the servo valve (4) and a sealing guide (902) of the plunger (9) for actuating the servo valve (4).

35 7 pages of drawings appended.

Servo valve for a fuel injection valve

Abstract

The injection valve has a control chamber (1) which can be acted on with fuel under system pressure and which can be connected to a fuel tank via a discharge restrictor (3) having an unpressurized return (21). The fuel flow to and from the control chamber (1) is controlled by a servo valve (4). In a first alternative, the discharge restrictor (3) is designed as a movable piston (3A) with a discharge opening (301) which is arranged between the control chamber (1) and the servo valve (4), the piston (3A), when there is a flow of fuel into the control chamber (1), opening feed openings (302) which are closed when there is a flow of fuel out of the control chamber (1). In a second alternative, the discharge restrictor (3) is designed as a cross section narrowing (3B) in a connecting bore (19) between the servo valve (4) and the control chamber (1), the cross section of the narrowing (3B) decreasing gradually down to a minimum in the direction of the longitudinal axis of the connecting bore (19) and then widening discontinuously again to the diameter of the connecting bore (19). In a third alternative, the discharge restrictor (3) is arranged in the return (21) after the servo valve (4).

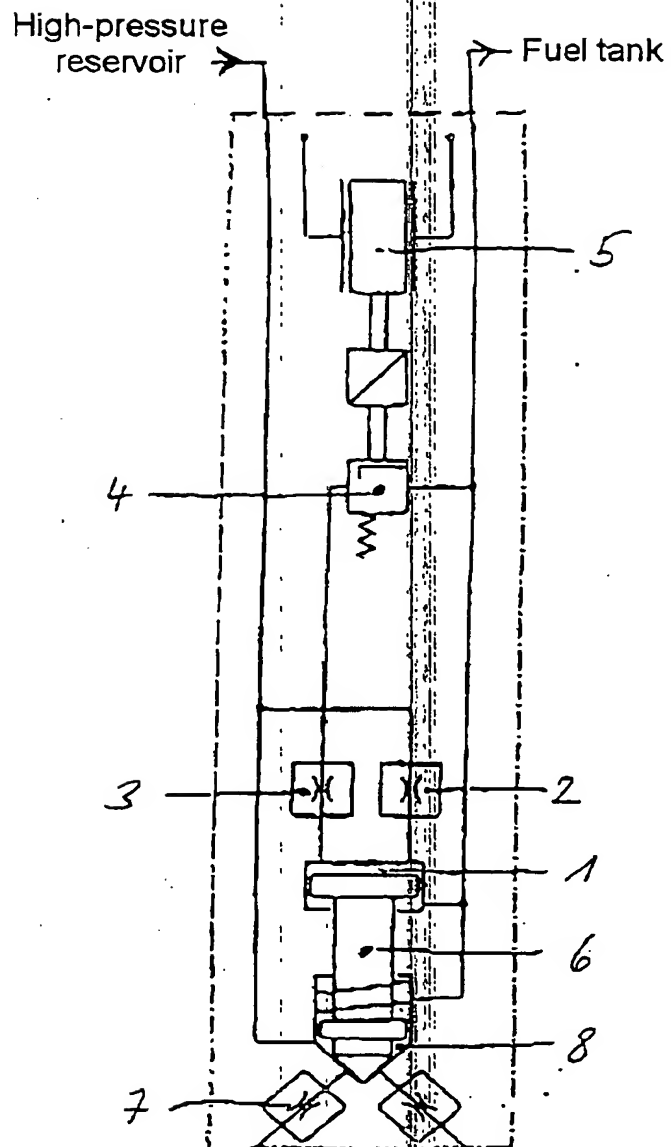


Fig. 1

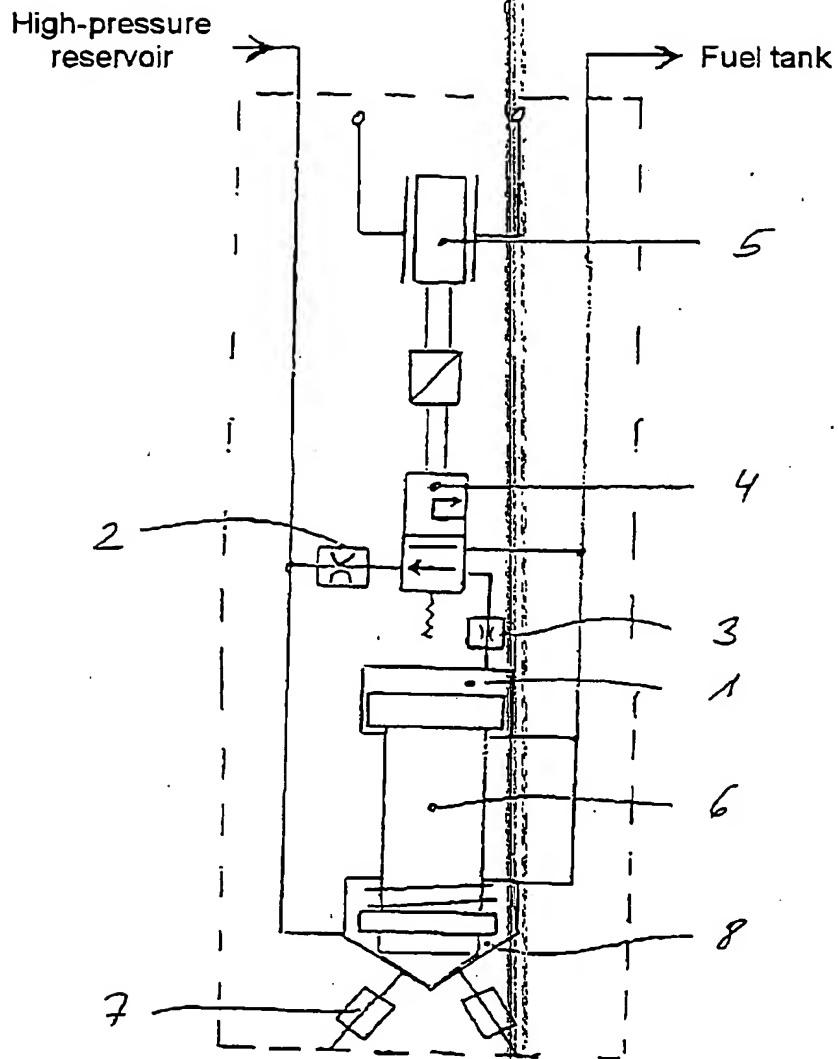


Fig. 2

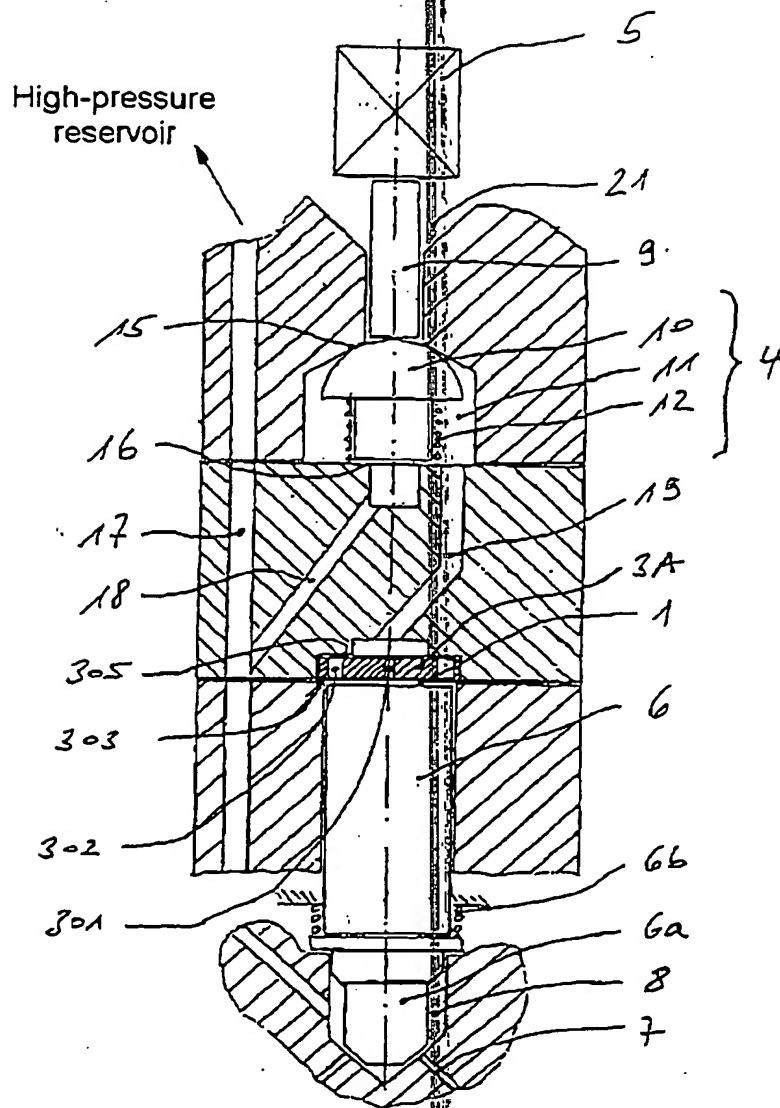


Fig. 3A

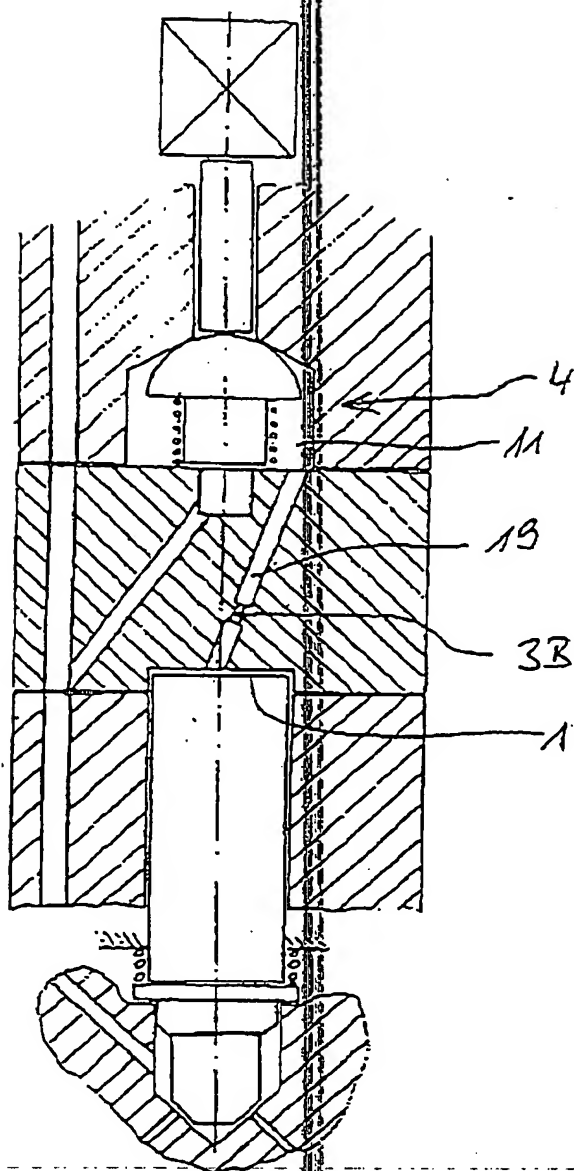


Fig. 3B

Number:

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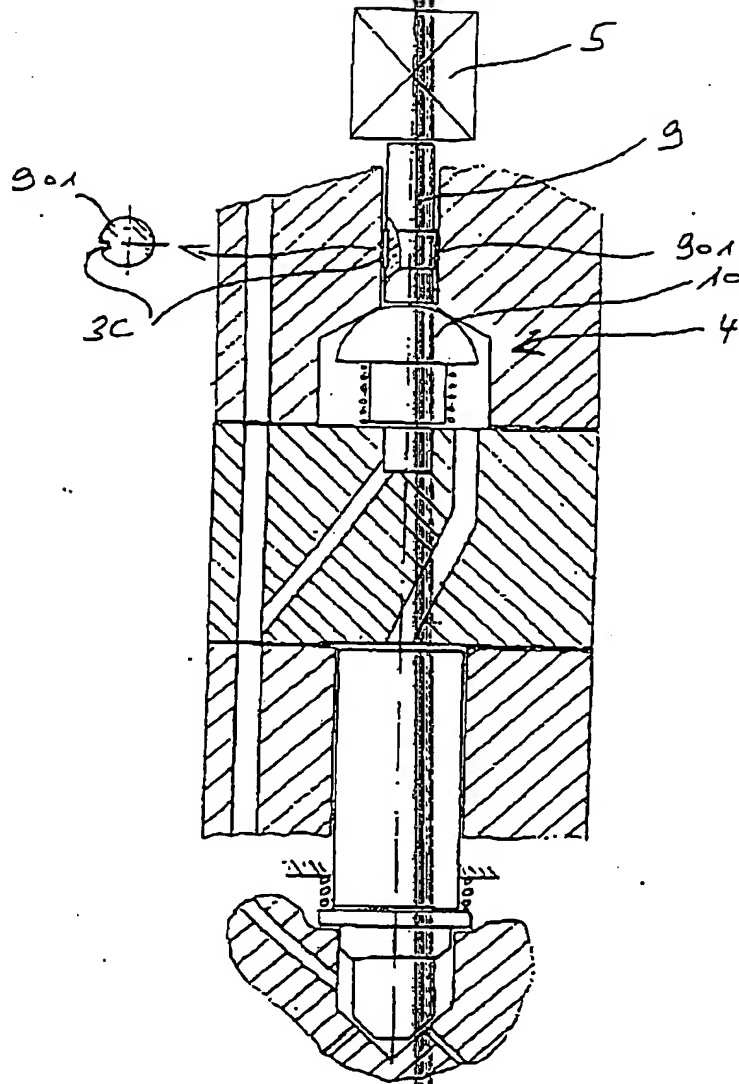


Fig. 3C

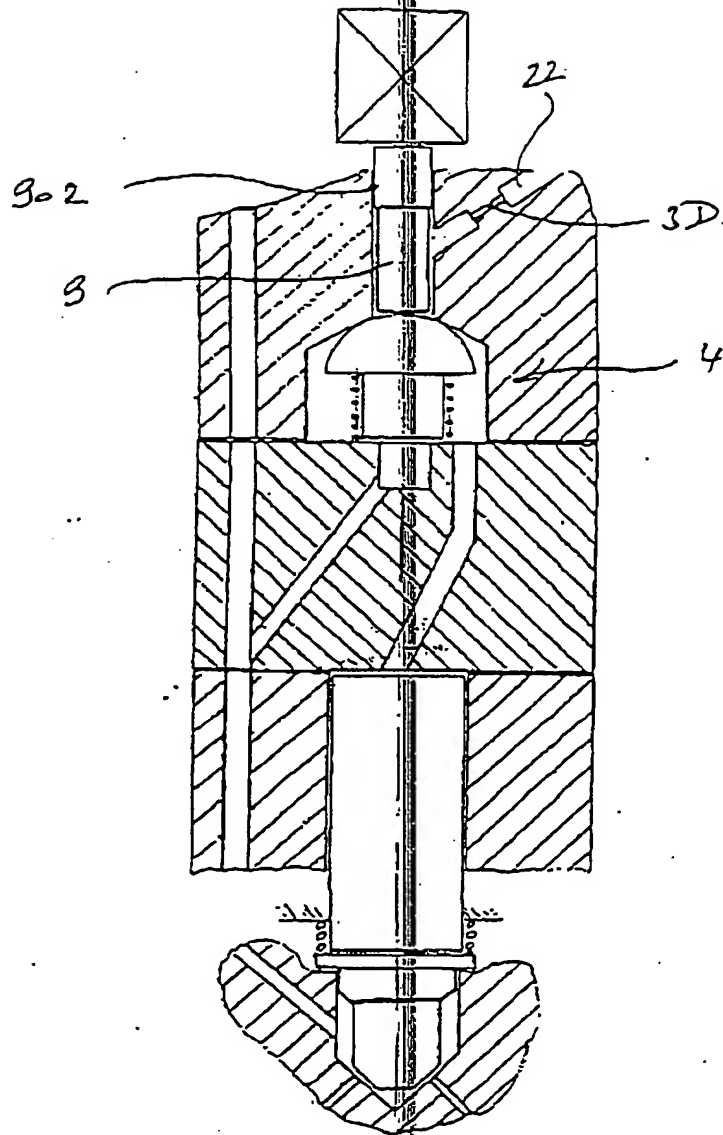


Fig. 3D

Number:

DE 198 23 937 A1

Int. Cl.⁶:

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Date laid open:

2. December 1999

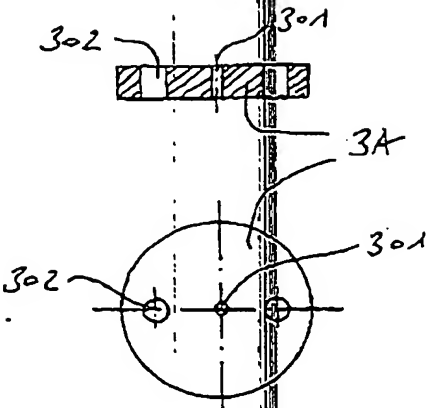


Fig. 4

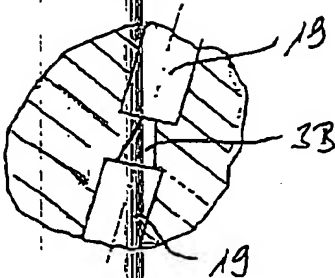


Fig. 5

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